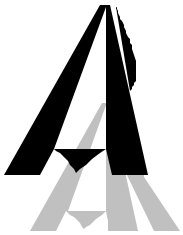

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The World Agricultural Trade Simulation System WATSIM

An Overview

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The World Agricultural Trade Simulation System – An Overview

Abstract

This paper presents a general overview on the World Agricultural Trade Simulation System WATSIM, the international trade modelling system of the Institute for Agricultural Policy at Bonn University. The system consists of two submodels, dealing with two major aspects of agricultural world markets: In the medium term the impacts of changes in agricultural policies on regional and international markets are of major interest and hence are stressed in the Medium-Term Policy Simulation Model. Developments in natural and socio-economic variables become even more important for supply and demand of agricultural products in the longer run, depicted in the Long-Term Shift Factor Simulation Model. Before presenting the features of the two sub-models, the main characteristics of the system are briefly discussed, pointing out the importance of using both the database and the partial equilibrium module jointly.

Zusammenfassung

Dieses Diskussionspapier gibt einen kurzen Überblick über das World Agricultural Trade Simulation System WATSIM, das Handelsmodellsystem des Instituts für Agrarpolitik der Universität Bonn. Die beiden Sub-Modelle decken in ihrer zeitlichen und inhaltlichen Differenzierung zwei der wesentlichen Fragestellungen im Bereich der landwirtschaftlichen Weltmärkte ab: Während mittelfristig der Einfluß veränderter Agrarpolitik im Vordergrund steht und deshalb Kern des Medium-Term Policy Simulation Model ist, gewinnen insbesondere auf längere Sicht Veränderungen natürlicher und sozioökonomischer Rahmenbedingungen für die Entwicklung auf den landwirtschaftlichen Märkten an Bedeutung. Sie werden im Long-Term Shift Factor Simulation Model dargestellt. Bevor die Besonderheiten der beiden Sub-Modelle beschrieben werden, werden die wesentlichen Charakteristika des Modellsystems in Kürze dargestellt, wobei auf die Bedeutung der gemeinsamen Nutzung von Datenbasis und zentralem Modul zur Bestimmung des partialen Gleichgewichts durch beide Sub-Modelle hingewiesen wird.

1 Introduction

1.1 Historical Background and Aims of the Modelling Work

The WATSIM model was developed in its first steps at the end of the 80's under the name SPEL TRADE on behalf of the EU Commission at the Institute for Agricultural Policy, Market Research and Economic Sociology of the Bonn University (IAP) under the direction of Prof. W. Henrichsmeyer (Henrichsmeyer 1995). It was the target to create an extensive and consistent database over world-wide production, demand and trade of agricultural products. On this basis, analyses of ex-post developments, as well as projections and policy simulations at world market level were performed.

Based on this older version, today a set of two modelling projects is developed, corresponding to the two-fold interest in having information on the development of agricultural world markets:

On the one hand, the need for further investigation of policy implications and for information on effects of agricultural policies on agricultural world markets has led to the Medium-Term Policy Simulation Model. Based on trend and expert oriented projections of the developments within the next 10 to 15 years, this model serves to simulate effects of agricultural policy changes on trade and world market prices as well as the representation of the global implications of agricultural protection.

On the other hand, the interest for a better understanding of the implications of changes in natural and socio-economic variables for long-term trends in production, demand, trade and prices on agricultural markets is addressed by a second sub-model, concentrating more on the shift factors both on the supply and demand side of agricultural markets. The Long-Term Shift Factor Simulation Model explicitly considers those shift factors rendering projections for the long run of about 20 to 25 years much more reliable. Additionally, changes in one or more of these variables can be investigated with respect to their impact on the long-term development of agricultural markets.

Of course, there is a third major field where this modelling framework could be used: To analyse the impact of sudden shocks on the deviation of the market development from the medium- and long-term trend, a Short-Term Shock Simulation Model should be realised in addition to the two mentioned systems. This sub-model, however, is not yet available, nor does the IAP have the resources for it within the current projects. For completeness, however, the need for this third model

should be kept in mind, even though it will not be mentioned within this overview on the WATSIM system.

1.2 Structure of the paper

This paper will be organised as follows:

The next chapter presents the general framework of the modelling system, which is common to both the Medium- and the Long-Term models.

Part three outlines the implementation of various policy measures in the medium-term model.

The fourth chapter deals with the representation of the different natural and socio-economic shift factors influencing supply and demand on agricultural markets, particularly in the long run.

The paper is concluded by a short summary and some statements on the current state of the projects. An outlook on future steps is given as well.

2 General Framework

Used by both the medium-term and the long-term model, a comprehensive and consistent data base is set up including data on supply, demand and trade quantities of agricultural products, prices and policy measures, price and income elasticities and macroeconomic variables on a single-country level. In addition, the basic modelling framework, which is generally similar to other models used by various institutions, is common to both of the WATSIM models. Hence, these two aspects of the modelling work are discussed here before going into the details of the sub-systems.

2.1 Data

Due to the disaggregated level with respect to both product coverage and the representation of demand activities, the WATSIM models heavily rely on the statistical data FAOSTAT, published by the Food and Agricultural Organization of the United Nations, FAO, Rome. Most of the data on supply, demand and trade, on land use and irrigation stems from this data base, supplemented by nutritional information on energy, protein and fat consumption, and prices. The data consists of time series covering the years 1961 to 1995, with additional data for 1996 to 1997 in parts. More recent data include the year 1996, but are not included into the WATSIM data base for the time being. The regional level of the data is the single country.

In order to fill gaps and to be up-to-date, but also because of the country level data on the Community of Independent States (CIS), the Production, Supply and Distribution (PS&D) data base published by the United States Department of Agriculture, USDA, Washington, D.C., is included as well. It comprises a smaller set of the most important agricultural products, with data on production, trade and the main kinds of utilisation on a single country level. The time series cover the years 1961 to 1997, recent publications even include 1998.

Macroeconomic data are taken from World Data 1995, published by The World Bank, Washington, D.C., and from the World Population Prospects, The 1996 Assessment, published by the United Nation, New York.

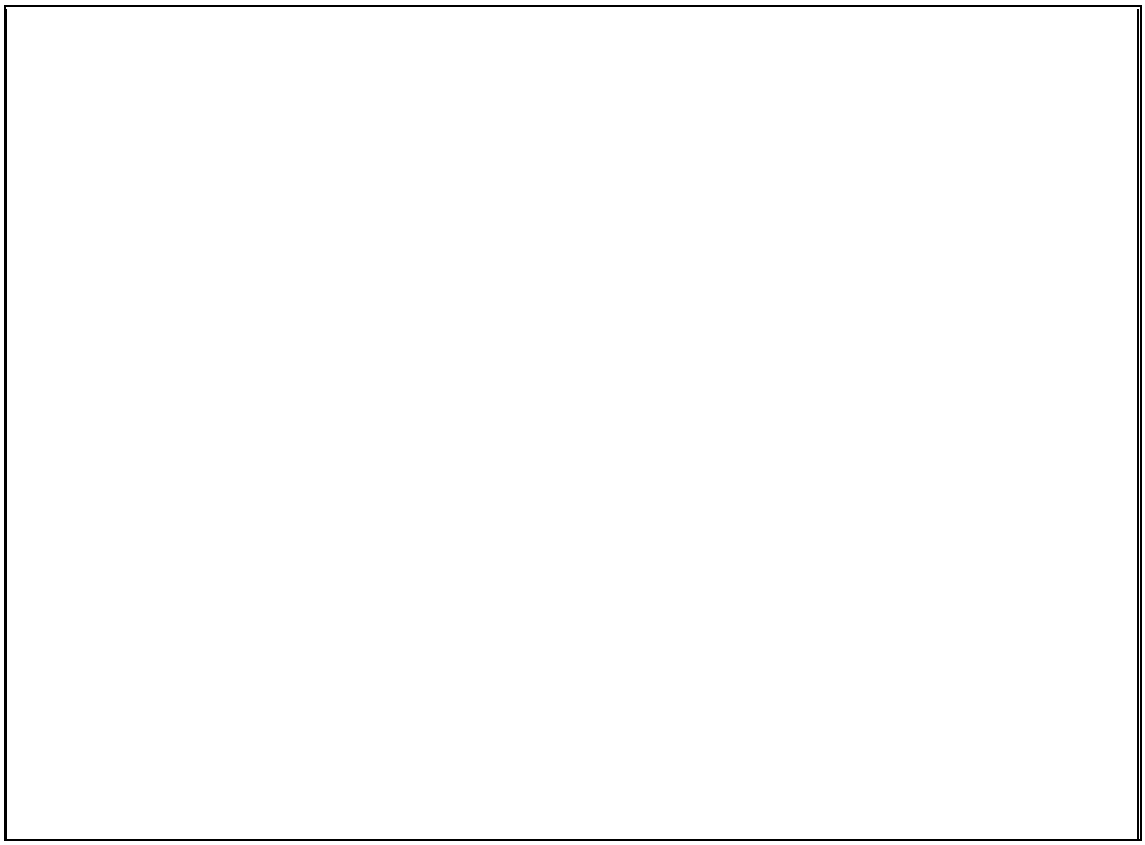
Most price and income elasticities are taken from the data base of the Static World Policy Simulation (SWOPSIM) modelling framework, published by the USDA. Policy parameters for the developed countries are taken from the Producer and Consumer Subsidy Equivalent 1997 Edition, published by the Organisation for Economic Co-operation and Development, OECD, Paris. OECD also published PSE/CSE-data for countries in Central and Eastern Europe.

Other sources were used for prices, elasticities etc.

The data from various sources are brought together in one single data base, thereby ensuring the consistency with respect to regional supply-utilisation balances, coefficients of yields and extraction rates etc.

After all, the data are aggregated to the level used in the WATSIM model via highly flexible program routines developed at IAP. Figure 1 shows the regional differentiation currently used in the WATSIM models:

Figure 1: Regional differentiation of the WATSIM model



Source: WATSIM -Team, Institute for Agricultural Policy, Bonn

The current WATSIM models comprise 29 products, both crops and livestock, and both raw and derived products. They include five groups of grains (wheat, barley, maize, other cereals and rice), starchy products, sugar, pulses, four groups of oilseeds (soybeans, sunflower seed, rapeseed and other oilseeds) and the corresponding oils and cakes, four groups of meat (beef including veal, pork, poultry and other meat), eggs, fresh milk and three groups of milk products (cheese, butter and cream, and skim milk products).

2.2 Parameter handling

Price and income elasticities coming from the literature are calibrated to ensure consistency with microeconomic theory. This is done assuming profit maximisation of both the agricultural sector (i.e. the production of agricultural raw product and the utilisation of agricultural products as feeding stuff) and the industrial sector (i.e. the crushing of oilseed, and the industrial processing of milk), and utility maximisation of consumers.

2.3 General outline of the economic equilibrium model

In general, the WATSIM model can be characterised as follows:

Comparative static: While the simulation outcomes for some target year is to be compared with the base year (currently 1994) or with some outcome of another simulation for the same target year, no information can be drawn about the adjustment path between base and target year. To overcome the disadvantages connected with this characteristic, projections and simulations may be done for a set of different target periods.

Deterministic: For all processes risk free conditions and average conditions, in particular for the weather, are assumed. The model is non stochastic. Consequently, risk behaviour is not represented. Stock changes are not endogenously modelled in WATSIM.

Non-spatial: The world market is represented as a point market and bilateral trade flows are not modelled. Furthermore, domestic and imported quantities of a product are assumed to be perfect substitutes in consumption.

Synthetic: The parameters, in particular elasticities, are not estimated. They originate from other models and the literature and are calibrated to fit the theoretical conditions derived from microeconomic theory.

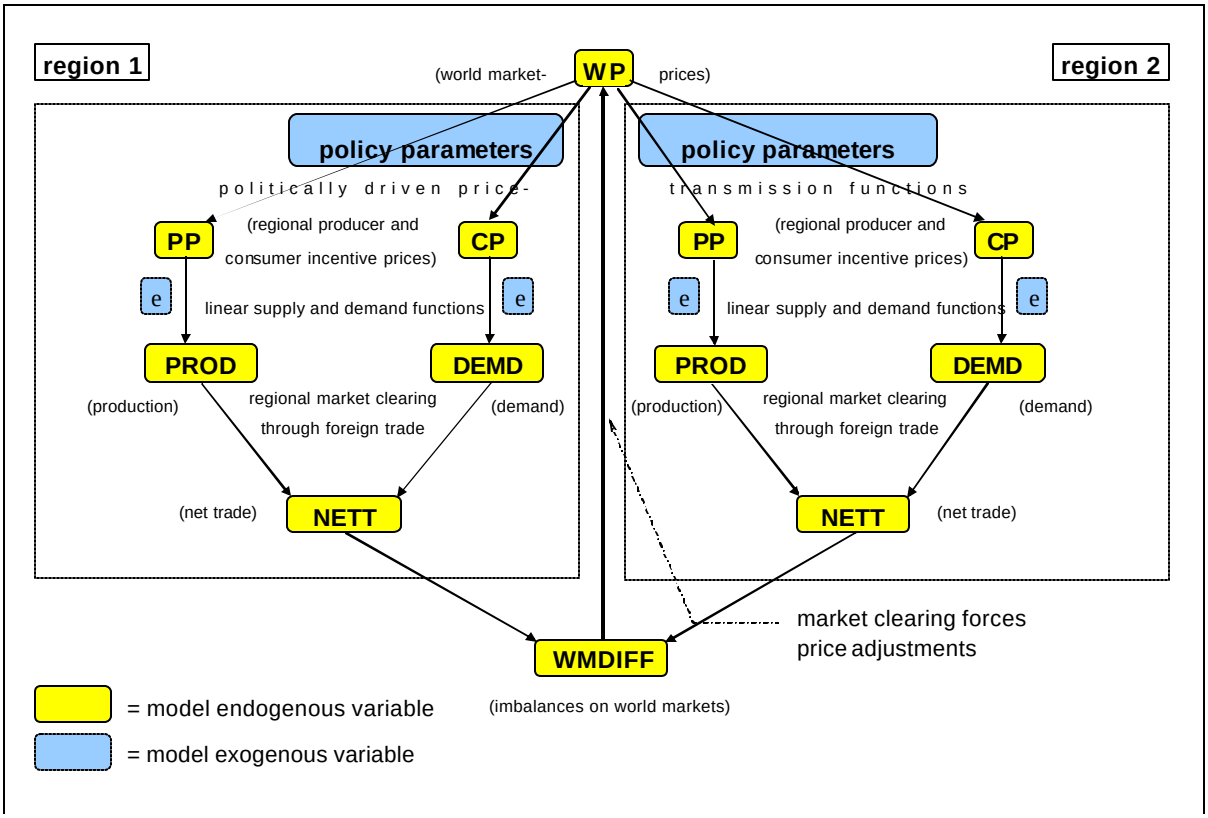
Multi-region, multi-product: The entire world is divided into 15 regions, whereby the database permits alternative aggregation levels. World and regional markets are currently differentiated into 29 products. Plant, animal, raw and processing products are considered.

Partial equilibrium model: Exclusively agricultural products are considered. All variables outside the agricultural sector, including factor availability and factor prices, are assumed to be exogenous and not influenced by changes on agricultural markets.

Figure 2 illustrates the principal mechanisms of the partial equilibrium model, which allows for the representation of the economic adjustments of supply and demand to exogenous changes. This heart of the model is straightforward and similar to other partial equilibrium models. The world markets for agricultural products come to an disequilibrium, if supply and demand exogenously shift away from their base year values. In addition, policies may change and cause further imbalances, if world market prices are fixed. The equilibrium algorithm then searches for a vector of new world market prices, which, transmitted into the regional markets via some price transmission functions, causes the

very adjustments of supply and demand necessary to bring world markets back to equilibrium, where net exports and net imports of all regions sum up to zero.

Figure 2: Sequence of the WATSIM model (schematic, simplified)



Source: WATSIM-team, Institute for Agricultural Policy, Bonn

3 Medium-Term Policy Simulation Model

To picture regional and global market reactions to agricultural policy modifications, in particular during the preparation of the pending World Trade Organization negotiations, the existing model system was updated with regard to current agricultural policy measures. According to the problem at hand, the system is used in the medium-term version, i.e. with a time horizon of approximately 10 years. Modifications of the world prices are transferred to the regional markets by the price transmission functions. Regional foreign trade or border prices differs due to quality differences as well as - depending on the net trade position - the transport costs. The market price support is situated between the border prices and the market prices as ad-valorem and specific tariffs or by a determined minimum price level, for example in the case of intervention.

Suppliers and consumers, however, not only react to the *'farm gate price'*, but also to other product-related payments or loads. These effects are incorporated in the concept of *producer (consumer) incentive prices*. Beside the measures which directly change the incentive prices for producers and consumers, other political measures are accounted for in the WATSIM which either subsidize the input use (premiums related to the cultivated area or animal number) or control quantities directly (production quotas, set-aside obligations, export restrictions):

Factor-related premiums

Factor-related premiums, are paid at present in the European Union for the harvested and set-aside area of the Grandes Cultures and for cattle, and they are also proposed for milking cows. In WATSIM they can be specified by separating production into harvested area (or animal numbers) and yields. In this context the premiums represent a price-similar incentive for the expansion of the production levels.

Production quotas

The quotas for the milk and sugar production, for example implemented in the European Union are reflected in WATSIM by price-independent fixing of supply quantities at the respective quota level.

Set-aside

Set-aside obligations are considered product specific by adjustment of the production area.

Export restrictions

The WATSIM incorporates quantitative export restrictions by introducing upper limits for export quantities directly. However, since WATSIM represents only the net trade of a region, import restrictions cannot be represented for net exporters. This has to be considered when creating scenario assumptions concerning admissible export quantities and interpreting the results.

The work on the Medium-Term Policy Simulation Model is done on behalf of and financed by the Commission of the European Union, Brussels.

4 Long-Term Shift Factor Simulation Model

In order to make the WATSIM model capable to represent and simulate changes in the socio-economic and natural environment, which is the more important the longer the simulation horizon is to be, major exogenous variables are explicitly introduced into the Long-Term version. These *key variables* are considered to be the main quantifiable driving forces for supply and demand on

agricultural markets. Projections on the shift factors either were taken from other sources, such as the World Population Prospects (UN) and the World Economic Outlook (International Monetary Fund IMF), or are based on detailed time series analysis and checked with expert knowledge and information from the literature.

4.1 Shift factors on the supply side

Land availability

Land availability for crop production is strongly limited and partly even decreasing in most regions of the industrialised world, but also in several developing countries in Asia, under the pressure of land needs for other purposes (e.g. urbanisation, industrialisation and infrastructure). Further expansion of crop production area is possible and expected particularly in Africa, Latin America and in some countries of the ASEAN rim. Much more important, however, is the intensification of land use: For most regions an increase in the cropping intensity is expected: More market crops will be harvested within one year on the same land, a development much more important with respect to the increase of agricultural production than the cultivation of new land. Projections on both total land availability and cropping intensities are based on time series analysis, explicitly taking into account the impact of urbanisation.

Irrigation

An important factor with respect to both cropping intensities and crop yields, the share of irrigated land is explicitly considered to formulate crop production developments. Projections on irrigation are based on time series analysis and checked against information from the literature.

Developments in feed regimes and feed efficiency

The changes both in feed regimes and feed efficiency is crucial in determining the future needs of the livestock sectors. On the one hand, a further improvement in feed efficiency can be expected throughout the world due to breeding and technological developments. In many regions, particularly in the developing world, however, the development towards a more market oriented, larger-scaled production of animal products will also lead to higher shares of marketable products in the feed regimes and thus increase energy inputs from marketable feeding stuffs per unit of animal product. Feed requirement parameters were estimated as feed energy intake per kg animal product and were projected via time series analysis and expert knowledge.

Other technical progress

Technical progress, particularly due to modern breeding and biotechnological research, has tremendous potential impact on productivity. This aspect is difficult to quantify and is captured mainly by trend estimation and supplemented by expert knowledge.

4.2 Shift factors on the demand side

Population growth

By modelling human consumption as per capita demand, the consideration of population growth, projected by the UN, is straightforward.

Income development

Further growth in income, approximated as real gross domestic product per capita, is one of the most important driving sources for the development of consumption growth on agricultural markets, particularly in the developing countries. By modelling income elasticities as a function of real income, changes in the response to income growth over time due to higher income levels are explicitly accounted for. Income projections were derived from the World Economic Outlook (IMF).

Urbanisation

Independent of income growth, urbanisation has proved to have significant impacts on consumption patterns: Wheat, sugar and particularly animal products are consumed more in urban areas compared to rural areas even with per capita income held fixed, while rice, coarse grains, starchy product and pulses are consumed less. Like the projections on total population, urbanisation figures were taken from the World Population Assessment.

The work on the Long-Term Shift Factor Simulation Model is done on behalf of and financed by the German Federal Ministry for Food, Agriculture and Forestry, Bonn.

5 Summary and Conclusion

The World Agricultural Trade Simulation System WATSIM is a group of currently two sub-models, designed to project and simulate the developments on agricultural world markets with two different focuses: In the medium term, impacts of agricultural policies with respect to trade restrictions and domestic measures on agricultural production, demand, trade and prices are investigated. In the long term, developments are widely dominated by changes in natural and socio-economic conditions like

land availability and income growth. The two sub-models jointly use a comprehensive and consistent data base, and also work with the same algorithm to solve for market equilibrium in some target year. This allows for synergy effects which are necessary to make projects like these feasible. The subsystems differ in their focus, which in turn depends on the time horizon of the analysis. The borders between the two of them, of course, cannot be drawn rigorously: Changes in socio-economic conditions do matter not only in the long run, but also have strong impacts in the short and medium term as, for example, the Asian crisis shows. Agricultural policies, on the other hand, also influence the developments on agricultural markets after year 2010. However, due to the fact that the impacts of political changes on average development on world markets diminish relative to the consequences of changed macro-economic conditions, this differentiation highlights the two different principal driving forces of agricultural markets.

A third aspect of investigation, the analysis of short-term shocks on agricultural markets as observed in the last years, will have to supplement the set of the WATSIM models. Today, this component is discussed and the need for it is realised, but further resources will be necessary.

For the time being, the WATSIM baseline up to year 2020 is prepared. It will include the projection under the political conditions set by agreed reforms and contracts (Uruguay Round, CAP-Reform, FAIR-Act etc.). The completion is scheduled for the end of October 1998. In order to have some idea of the development between the current base year 1994 and this target year, the baseline will also include the years 2005 and 2010.

The simulation of policy changes, which can be anticipated with regard to the pending WTO negotiations, as well as sensitivity analysis with respect to the assumed developments in socio-economic conditions will be the next steps towards a useful instrument for policy information.

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